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Study on Behavior of RCC Beam Column Joint With Special Confinement Subjected To Static Loading Numerical Investigation

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ABSTRACT

In all the framed structures particularly high rise buildings, beam column joints are the vulnerable portion when subjected to seismic loads. Its ductility and also the shear strength parameter influence the withstand ability against the seismic attack. It gives a significant knowledge about seismic performances of the structure.

This present study helps to provide an importance about the ductility and shear strength of the steel and also gives the variation in shear strength and deformations with the different provision of transverse reinforcement. Using finite element method, software called ANSYS was used to carry out the linear elastic analysis.

Keywords

Special Confinement, Transverse Reinforcement,Seismic loads & Ductility

1. INTRODUCTION

Reinforced concrete (RC) beam-column connections have been identified as potentially one of the weaker components when a reinforced concrete moment frame is the main Seismic Force Resisting System (SFRS). Numerous experimental and analytical studies have been performed since the mid-1960s to clarify the performance of RC beam-column connections subjected to seismic lateral loading. These studies identified that understanding joint shear behavior is important toward maintaining reasonable and ductile behavior, which is one of the most important factors in current seismic design philosophies for RC beam-column connections.

2. LITERATURE REVIEW

The literature review has been done to obtain the information about RCC beam column joints subjected to static loading. **Jaehong Kim and James M. LaFave -** A database of RCC beam column connection test specimens exhibiting joint shear failure when subjected to reverse cyclic loading. Parameters such as Concrete compressive strength, beam reinforcement, joint transverse reinforcement influencing the joint shear capacity were discussed

[5]. **S. S. Patil, S. S. Manekari -** Parameters such as maximum stress, minimum stress, stiffness variation of the external and corner joint was evaluated while subjected to monotonic loading. Plotted the load vs displacement graph, Maximum and minimum stress vs load of the different joints (exterior and corner) [7]. **S. Rajagopal *, S. Prabavathy -** Improvements were observed in seismic performances, ductility and strength while using proposed hair clip bar plus X cross bar in combination with mechanical anchorage detail for higher seismic prone areas. They concluded that Specimen with T type mechanical anchorage offers better performance with better control of cracks than conventional 90 degree bent hook anchorage. The use of mechanical anchorage results in the reduction of reinforcement and rebars congestion in the joint core area [8]. **S.V.Chaudhari, K.A.Mukane and M.A.Chakrabarti -** Numerical analysis had been done using finite element method by both Abaqus and Ansys software. It helped to have an improved understanding of finite element modelling. Load displacement behaviour was studied. Results from Abaqus and Ansys were compared [1]. **A. Hosseini, M.Marefat, A. Arzeytoon & J. Shafaei -** A finite element analysis had been conducted to study the seismic performance RC beam-column joints rehabilitated with new scheme. The steel angles were used at joints as bracing systems. This numerical study demonstrated significant strength and ductility improvement in a Rehabilitated RC beam-column joint [4].

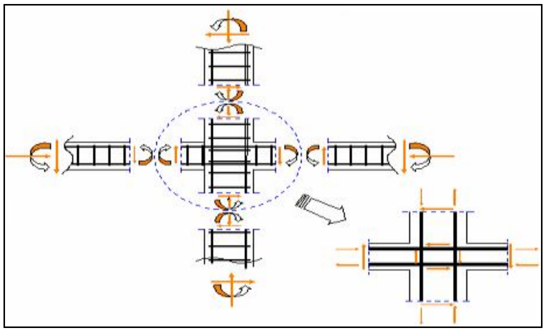
3. NUMERICAL INVESTIGATION

A. Framed Joints

The design of the beam column joint plays the major role in the strength of the structure. Interior & Exterior joints are considered for analysis.

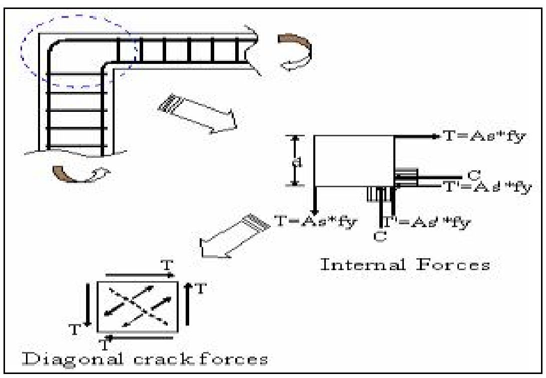
i. Exterior joint

An Exterior joint has at least two beams framing into opposite sides of the joint. To be classified as an exterior joint, the widths of the beams on the two opposite faces of the joint should cover at least ¾ the width of the column, and the depths of these two beams should not be less than ¾ the total depth of deepest beam framing in to the joint.



ii. Corner Joint

A Corner joint has at least one beam framing into the side of the joint. To be classified as a corner joint, the widths of the beam on the face of the joint should cover at least 3/4[th] the width of the column.



B. *Finite Element Method*

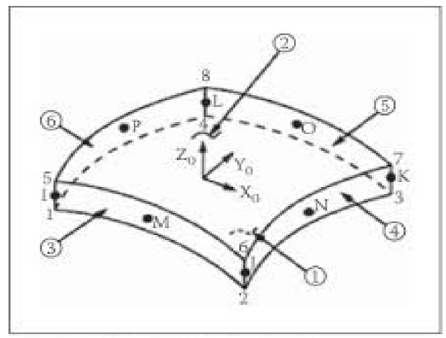
The numerical investigations had done by finite element method using ANSYS software. Modeling of the specimens were done by Auto cadd 3d and imported to the software for analysis.

i. Ansys programme

ANSYS is a commercially available finite element analysis software package for FEA. It is a general purpose Finite Element Modeling Package for numerically solving a variety of mechanical problems. These problems include static and dynamic structural analysis (both linear and non linear), steady state and transient problems, mode frequency and buckling analyses, acoustic and electromagnetic problems and various types of field and coupled-field applications. The program contains many special features which allow nonlinearities or secondary effects to be included in the solution such as plasticity, large strain, hyper elasticity, creep, swelling, large deflections, material anisotropy and radiation. The finite element program of ANSYS 12.0 Multiphysics version is used to develop a finite element model, which aimed to simulate the behaviour and strength of the cold-formed steel sigma, and C-section flexural members in the experimental program.

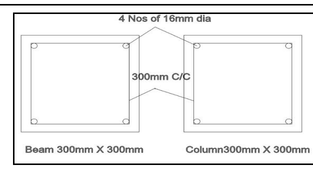
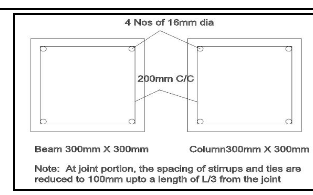
a. Element Type

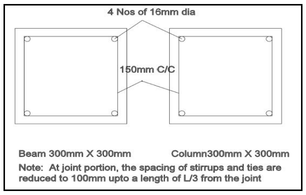
Specimens were modeled using shell 281. The element has eight nodes with six degrees of freedom at each node: translations in the x, y, and z axes, and rotations about the x, y, and z-axes. (When using the membrane option, the element has translational degrees of freedom only.) This element is well-suited for linear, large rotation, and/or large strain nonlinear applications. Change in shell thickness is accounted for in nonlinear analyses. This element may be used for layered applications for modeling composite shells or sandwich construction.



b. Specimen details

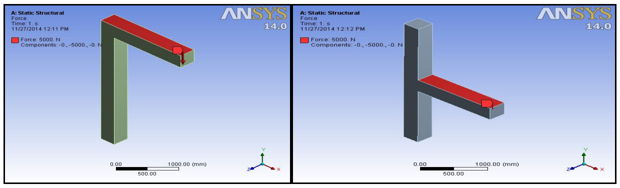
Table I Geometrical specification

Grade of concrete-M25	***Grade of Steel: FE 415***
Length of beam-1500mm	***Length of column-3000mm***
Location of Joints- Corner and exterior Frame	
Specimen no	***Cross section***
1	
2	

3	

a. Boundary conditions, loading.

3 specimens of corner joint and 3 specimens of exterior joint were tested with the boundary condition of fixed support at the ends of the column. The incremental loading values of 5 KN, 10 KN, 15 KN, 20 KN, 25 KN and 30 KN were applied at the end of the beam in the downward direction. The images of specimen's deformations and shear stresses are furnished here.



(a) (b)

Fig 1: Loading and boundary condition(a) corner joint (b) exterior joint

4. RESULTS AND DISCUSSION

The specimen consists of beam column joint at exterior and corner. Stirrups and ties spacing is reduced on the joint portion in specimen 2 & specimen 3. Static loading is applied from 5 kN to 30 kN at the end of the beam. Deformations and shear stresses are determined for all the specimens. Variation in deformations and shear stresses due to the loads are shown in figure.

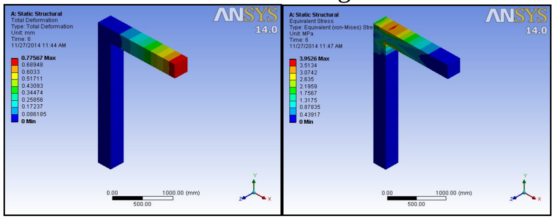


Fig 2: Deformation and shear stress in Specimen 1 at corner joint

The max deformation and max shear stress obtained here are 0.78 mm & 2.18 N/mm^2 respectively

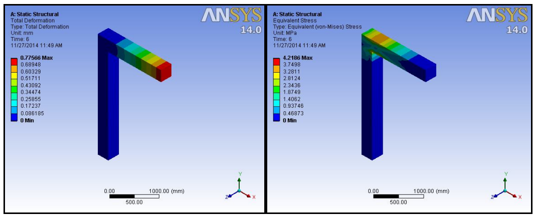


Fig 3: Deformation and shear stress in Specimen 2 at corner joint

The max deformation and max shear stress obtained here are 0.62 mm & 2.13 N/mm^2 respectively

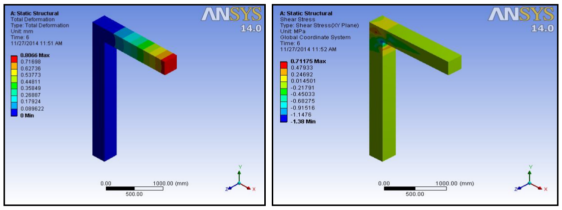


Fig 4: Deformation and shear stress in Specimen 3 at corner joint

The max deformation and max shear stress obtained here are 0.53 mm & 0.71 N/mm^2 respectively

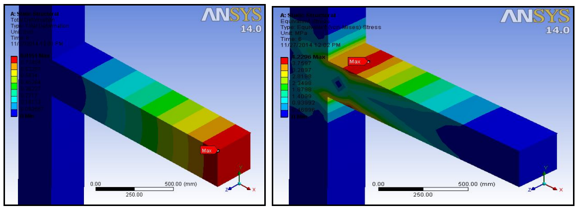


Fig 5: Deformation and shear stress in Specimen 1 at Exterior joint

The max deformation and max shear stress obtained here are 0.82 mm & 11.16 N/mm^2 respectively

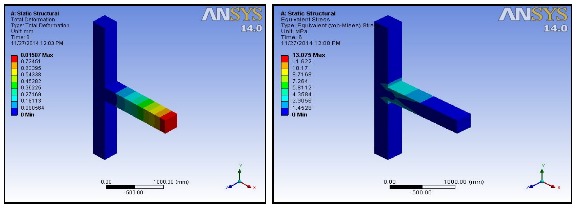


Fig 6: Deformation and shear stress in Specimen 2 at Exterior joint

The max deformation and max shear stress obtained here are 0.74 mm & 9.3 N/mm^2 respectively

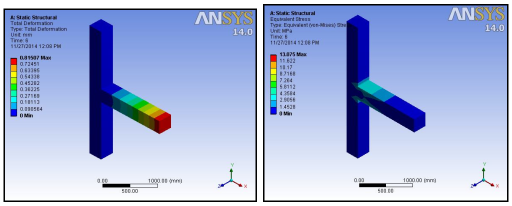


Fig 7: Deformation and shear stress in Specimen 3 at Exterior joint

The max deformation and max shear stress obtained here are 0.63 mm & 7.3 N/mm^2 respectively.

5. COMPARATIVE RESULT

A. Corner joint

1) Deformation

Deformations of the specimen1, specimen 2 and specimen 3 are compared. Out of these, the specimen with least transverse reinforcement subjected to a higher deformation than the other specimens with the same loading conditions

Table II Comparative results of all specimens in corner joint

Load (kN)	Deformation (mm)		
	Specimen 1	Specimen 2	Specimen 3
0	0	0	0
5	0.12928	0.1028	0.0872
10	0.25856	0.1856	0.1436
15	0.38783	0.2456	0.2188
20	0.51711	0.3472	0.2975
25	0.64639	0.5189	0.4282
30	0.77567	0.6152	0.5324

Specimen 2& 3 shows considerable decrease in deflection when compared with specimen 1

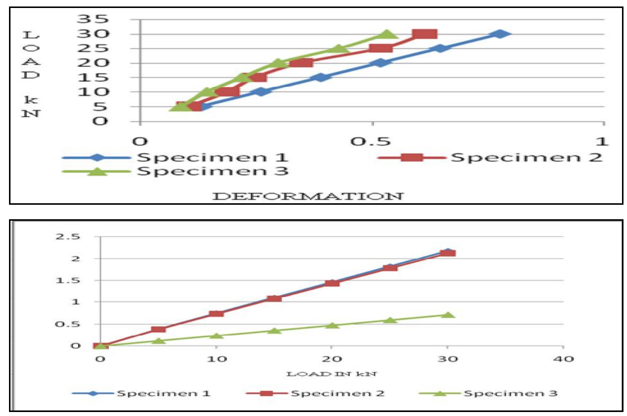
2) Shear stress

shear stress of the specimen 1, specimen 2 and specimen 3 are compared. Out of these, the specimen with least transverse reinforcement carries a higher value than the other specimens with the same loading conditions

Table III Comparative results of shear stress of all specimens in corner joint

Load (kN)	Maximum shear stress (N/mm^2))		
	Specimen 1	Specimen 2	Specimen 3
0	0	0	0
5	0.38875	0.38564	0.11978
10	0.74715	0.73396	0.23832
15	1.1055	1.0823	0.35667
20	1.4639	1.4306	0.47503
25	1.8223	1.7789	0.59339
30	2.1807	2.1273	0.71175

When compared with specimen 1 it shows decrease in shear stress of specimen 2&3



(a) (b)

Fig 1 load vs deformation (b) load vs shear stress

B. Exterior joint

1) Deformation

Deformations of the specimen1, specimen 2 and specimen 3 are compared. Out of these, the specimen with least transverse reinforcement subjected to a higher deformation than the other specimens with the same loading conditions

Table IV Comparative results of deformation of all specimens in exterior joint

Load (kn)	Deformation (mm)		
	Specimen 1	Specimen 2	Specimen 3
0	0	0	0
5	0.13585	0.1128	0.0987
10	0.2717	0.2156	0.1876
15	0.40755	0.3257	0.2987
20	0.5434	0.4232	0.3457
25	0.67925	0.5432	0.4876
30	0.8151	0.7389	0.6243

Specimen 2& 3 shows considerable decrease in deflection when compared with specimen 1

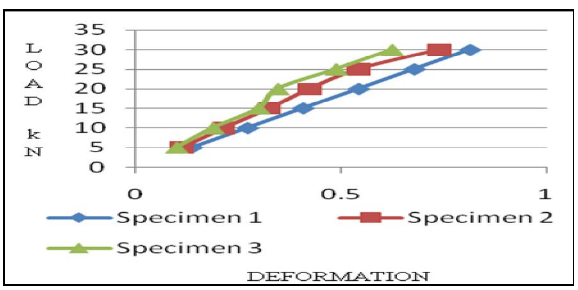
2) Shear stress

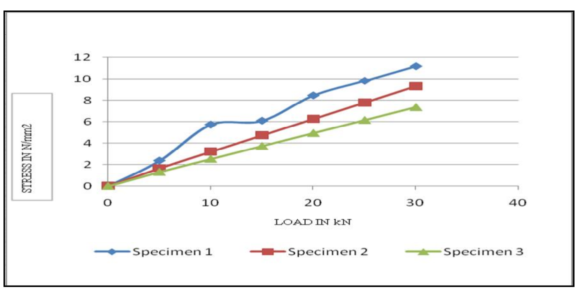
Maximum shear stress of the specimen1, specimen 2 and specimen 3 are compared. Out of these, the specimen with least transverse reinforcement carries a higher value than the other specimens with the same loading conditions.

Table V Comparative results of shear stress of all specimens in exterior joint

Load (kN)	***Maximum shear stress (n/mm^2)***		
	Specimen 1	***Specimen 2***	***Specimen 3***
0	0	0	0
5	2.3612	1.6639	1.3189
10	5.72276	3.2033	2.5339
15	6.0841	4.7307	3.7455
20	8.4455	6.2582	4.9575
25	9.8069	7.7858	6.1697
30	11.1683	9.3134	7.382

When compared with specimen 1 it shows decease in shear stress of specimen 2&3





(a) (b)

Fig 2 load vs deformation (b) load vs shear stress

6. CONCLUSION

ANSYS 14.0 was used to determine the equivalent stress, shear stress and deformation for all the specimens. From the results obtained, the following conclusions can be made based upon the numerical results.

- As per the numerical analysis, the deformation is lesser for the specimen which is having more transverse reinforcement at corner and exterior joints.
- The maximum shear is more for the specimen which is having the less transverse reinforcement. Hence the shear strength of the joint will be high for the specimens with special confinement.

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